Anti-deuteron Production and Baryon Phase-space Density from $Au+Au$ Collisions at RHIC

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In high energy nuclear collisions coalescence method has been used for light nuclei production. The success of the approach is essentially due to the small binding energy of the nuclei and the thermal like distributions for nucleons that form the light nuclei [1]. Interesting information on the freeze-out properties like baryon density and source 'size' can be extracted. More important baryon dynamic information can be extracted from such analysis.

The yields of the the light nuclei with nucleon number A and momentum P is related to the primordial nucleon yields at momentum $p = P/A$ through a coalescence parameter B_A,

$$E\frac{d^3N_A}{d^3P} = B_A(E\frac{d^3N_N}{d^3p})^A. \quad (1)$$

The parameter B_A, as a function of momentum, is inversely proportional to the source phase-space volume for the light nucleus formation and can be directly predicted from the nuclear wave function of the produced light nucleus. The yield ratio N_d/N_p therefore should reflect directly the phase-space density of the light nucleus d. Here N_d is the yield of deuterons and N_p is the yield of protons.

In this report, we present the preliminary STAR data on anti-deuteron production from $\sqrt{s_{NN}}$ = 200 GeV $Au+Au$ collisions. About 1.7M events were used in the analysis. Comparing with the STAR anti-proton production results from the same collisions, we extract the ratio of anti-deuteron over anti-proton [4] and discuss the physics implications. Due to the limitation in the particle identification in STAR TPC, we only extract the yields of anti-deuteron yield within rapidity $|y| \leq 0.5$ and transverse momentum $p_T \leq 0.9$ GeV/c. The total yield is extracted with the help of a blast-wave fit [5].

Figure 1 shows the energy dependence of the anti-deuteron yield over anti-proton yield ratios. The results from the present study is shown as star. Results from $p(\overline{p})+p$ [7], $p+A$ [6] and $A+A$ [2, 3] collisions are shown as open-squares, open-circles, and stars, respectively.

The ratio increases monotonically with colliding energy and might saturate at $\sqrt{s_{NN}} \approx 50$ GeV. Note that the results from $\overline{p}+p$ collisions are spread over energy from a few GeV to a few TeV [6, 7] and the level of saturation in N_d/N_p seems independent of either the colliding system or the energy. Since freeze-out process is local, the constant of the N_d/N_p ratios at $\sqrt{s_{NN}} \geq 50$ GeV perhaps means that the conditions for freeze-out in high energy collisions become similar in collisions at sufficient high energy.

Since the light nuclei formation probability is affected by the space-momentum structure of the constituent nucleons, it is therefore interesting to study the event anisotropy parameter v_2 [8] of the light nuclei. That analysis requires a much high statistics and PID at higher p_T . The work is underway.

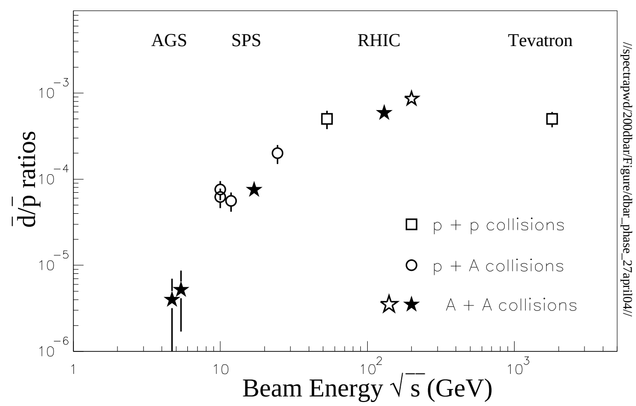

FIG. 1: N_d/N_p ratios as a function of beam energy. Results from $p(\overline{p})+p$, $p+A$ and $A+A$ collisions are shown as open-squares, open-circles, and stars, respectively. STAR preliminary result is shown as the open-star. At $\sqrt{s_{NN}} \geq 50$ GeV, the ratio seems to be saturated.

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